



Antipersonnel Landmine Alternatives

Self-Healing Minefield

***Portions of a Presentation Given to the National Academies
Committee on Alternative Technologies
to Replace Anti-Personnel Landmines***

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The Antipersonnel Landmine Alternatives Track II



- **Deputy Secretary of Defense directs DARPA in October 1997**
 - To execute Antipersonnel Landmine Alternative Track II study, which will focus on the development of alternatives to meet the requirements currently met by antipersonnel landmines
 - To “investigate maneuver denial approaches that may be more innovative and/or take advantage of advanced technologies.”
- **DARPA study methodology**
 - Alternatives should provide increased warfighting capability
 - Consider post conflict battlefield hazards
 - Unexploded ordnance, etc.
 - Conduct brainstorming with:
 - Industry
 - National Laboratories
 - Academia

The Antipersonnel Landmine Alternatives

Track II - Results



- **DARPA Track II Task Force briefed Dr. Hamre in June 1998 on potential alternatives:**
 - **Top Priority:** Self-Healing Minefield
 - Antitank system that permits the removal of antipersonnel landmines from minefields
 - Provides a novel complex obstacle that achieves maneuver denial
 - Addresses **only** the issue of antipersonnel landmines used in the “mixed” mine system

Antipersonnel Landmine Functions versus Alternatives

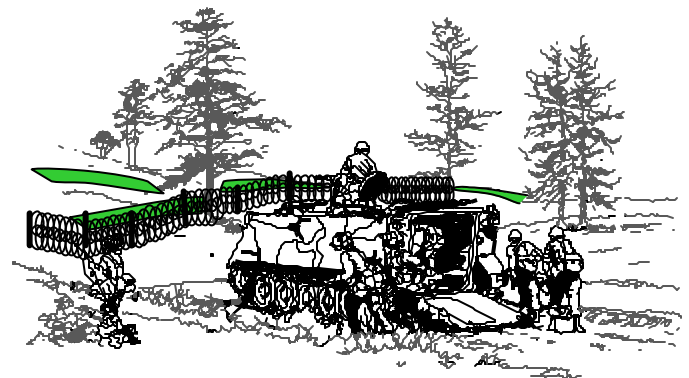


**Primary antipersonnel
landmine functions lost
with removal from
arsenal**

- **AT minefield
protection against
dismounted breach**

**Antipersonnel landmine
alternative technologies
(under investigation by
DARPA)**

- **Self-Healing Minefield**





Self-Healing Minefield

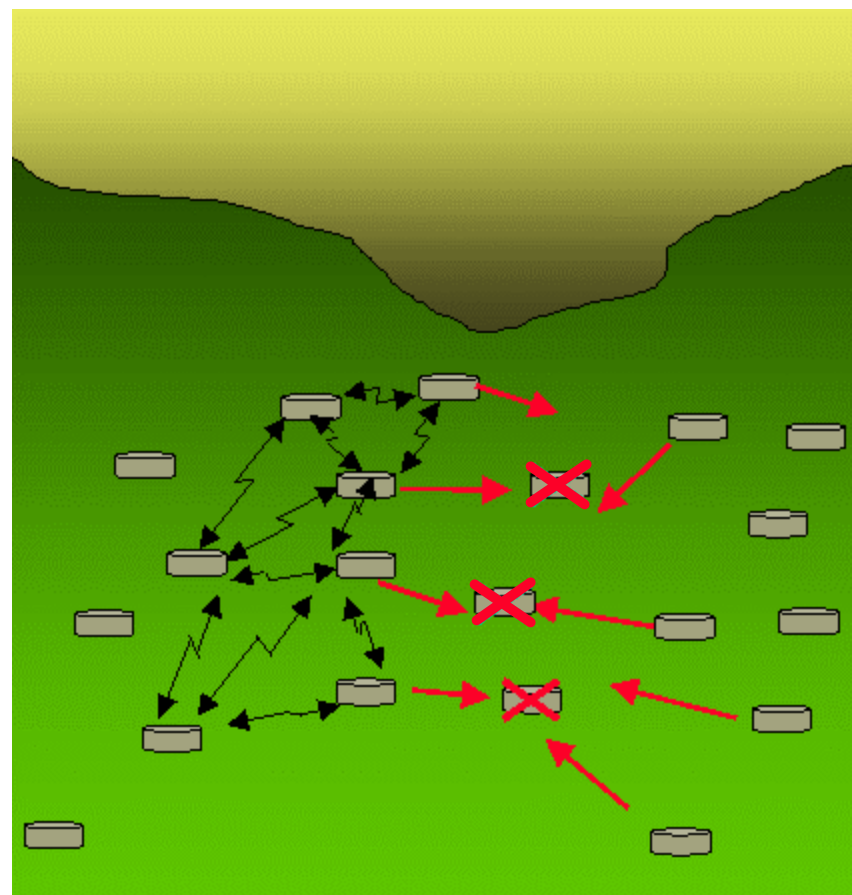
- Technical Concept



- The current Mixed Systems use antipersonnel landmines to complicate dismounted breaching and clearance of antitank minefields

Alternative approach:

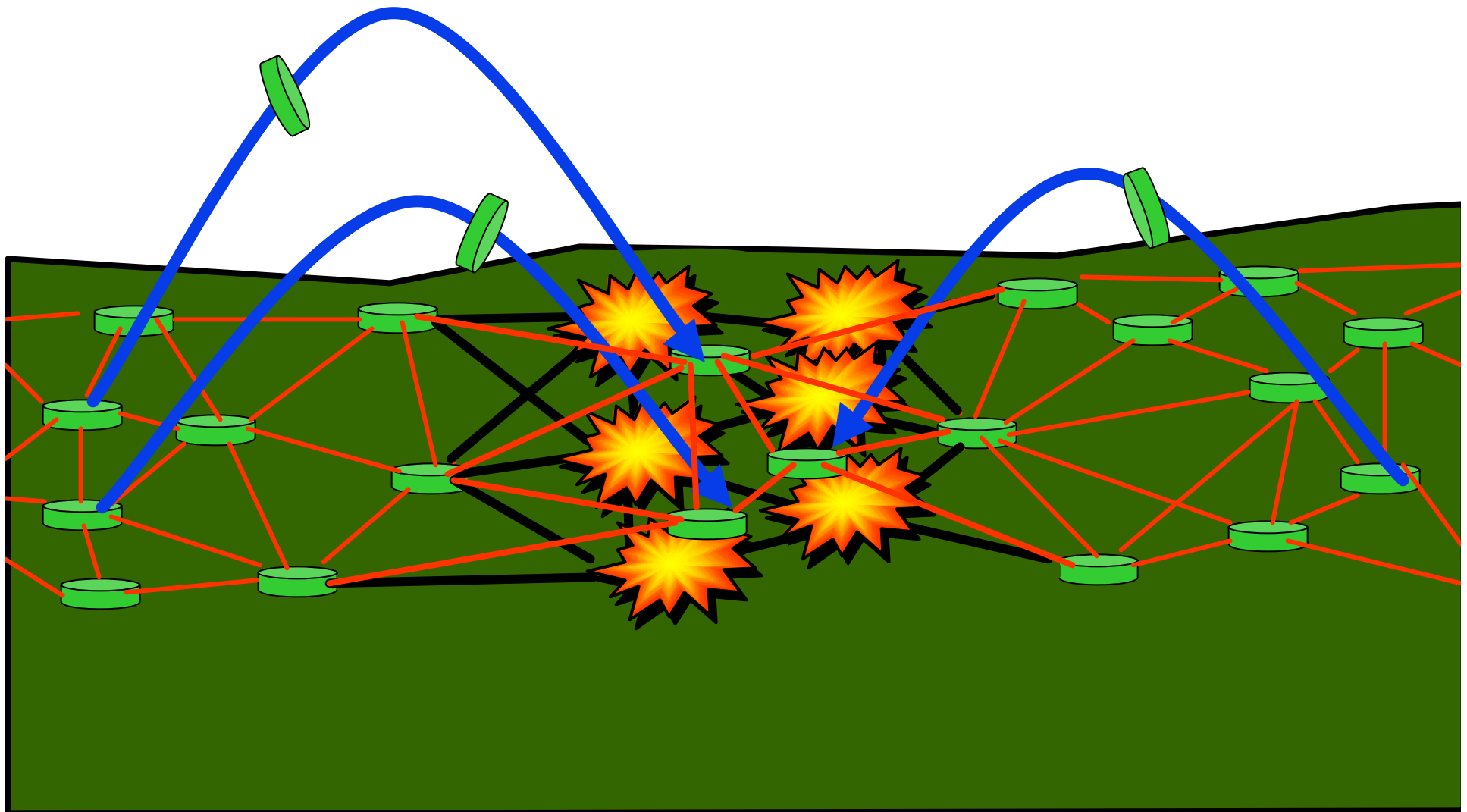
- **Dynamic** antitank minefield that preserves the obstacle
 - Scatterable antitank mine similar to Volcano or Gator in size and delivery method
 - Minefield detects a breaching attempt through mine-to-mine communication, interaction or collective sensing
 - Individual mines respond to the breaching attempt by reorganizing (moving) to fill in the open lane
 - Thus the barrier is re-established
 - Minefield is an autonomous distributed network with decentralized control
 - No man-in-the-loop
 - Minefield behaviors dependent on enemy attack



Minefield acts like a fluid - cannot sustain a breach



Self-Healing Minefield

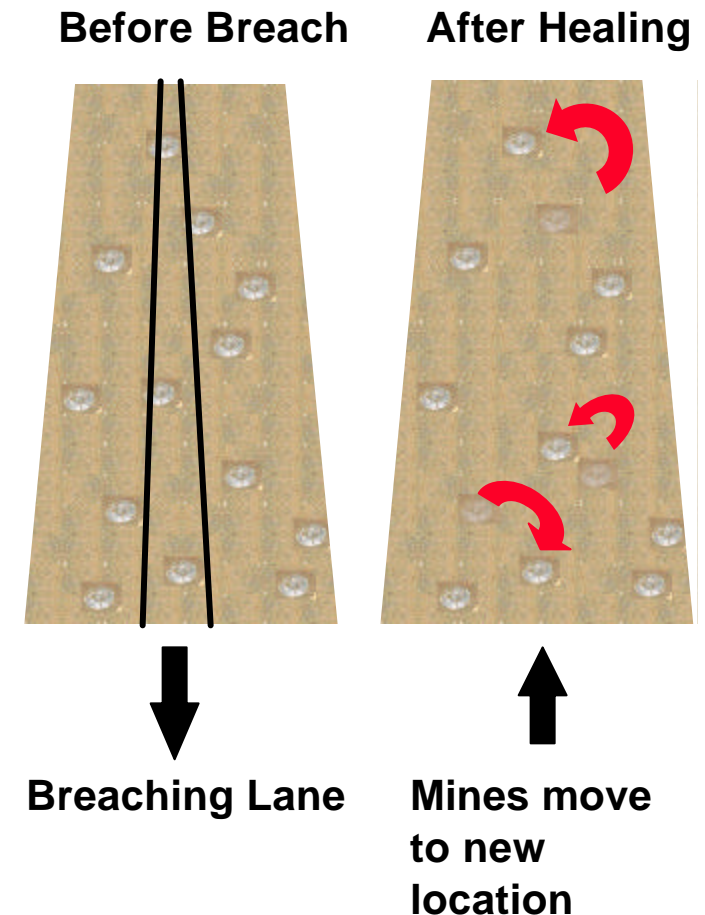




Self-Healing Minefield - Benefits



- **Self-Healing Minefield prevents/impedes a successful breach WITHOUT antipersonnel landmines**
 - Specific tactical effect is different from that of the current mixed system
- **Self-Healing Minefield forces the enemy to change antitank minefield operations from breaching to clearing**
- **Self-healing Minefield provides an opportunity for substantial dynamic control of the antitank minefield**
 - Potential on-off-on capability
 - Shift from single mine anti-tampering to collective anti attack mode





Self Healing Minefield - Programmatic Approach



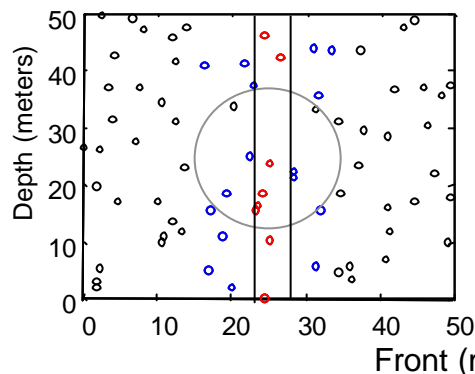
- **Preliminary analyses**
 - Assess the robustness against simple breaching
- **Battlefield utility**
 - Assess the system performance relative to existing capabilities
- **Research of enabling technologies**
 - Mine mobility
 - Mine to mine communications
 - Behaviors
- **Integrate and test surrogate minefield**
- **Transition to United States Army for development**



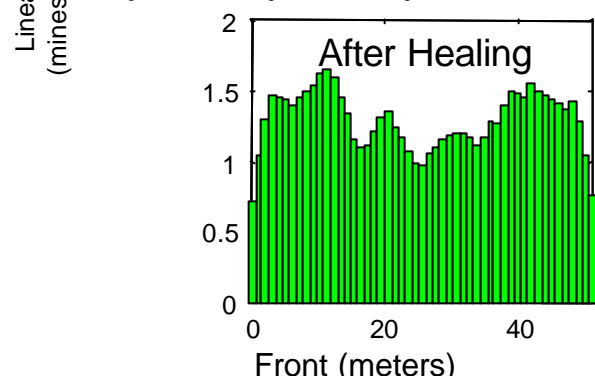
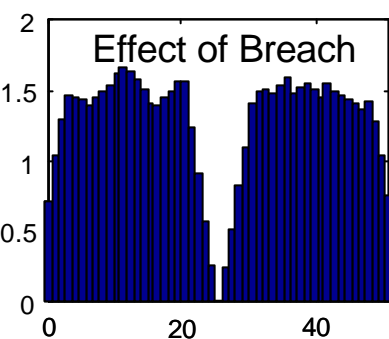
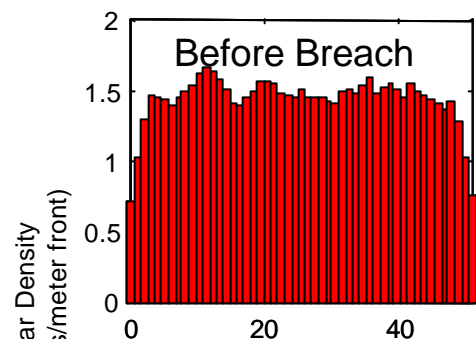
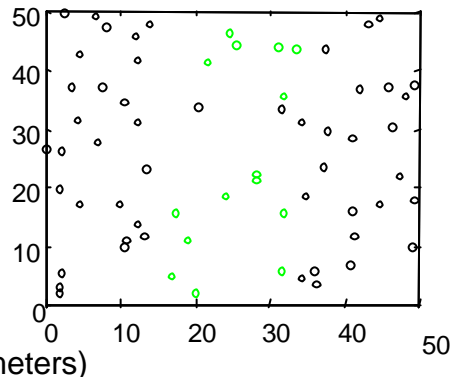
Self-Healing Minefield - Simple Analysis



Effect of Breach



After Healing



**No clear path
through
minefield after
breach attempt**

Source: Institute for Defense Analyses

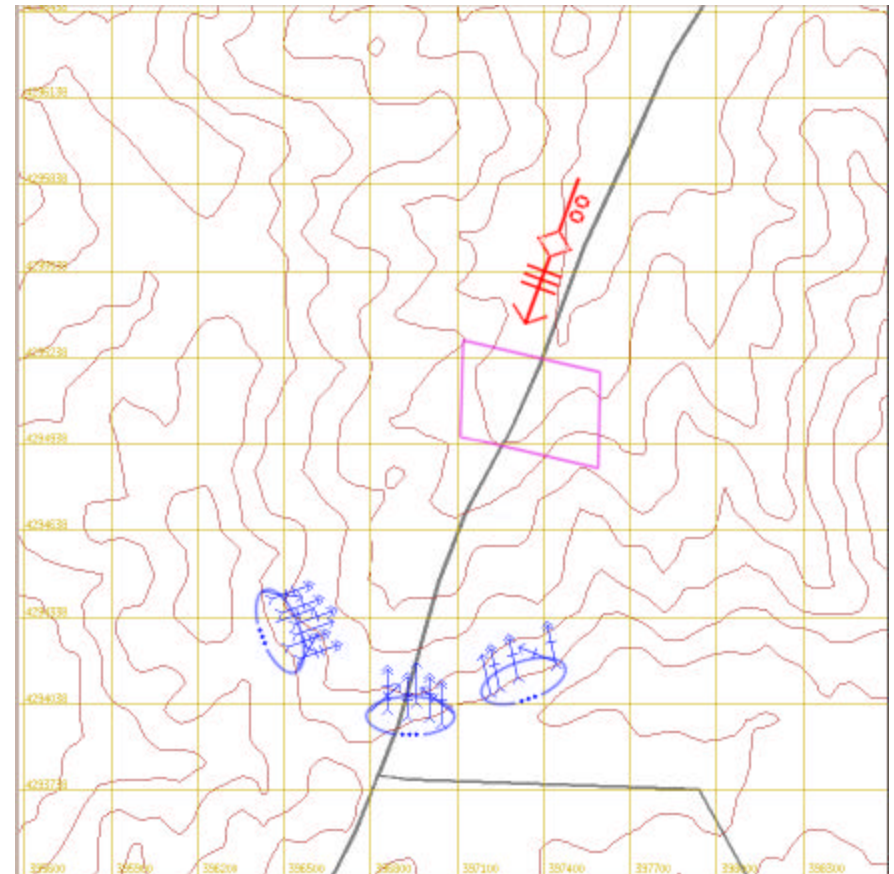
- **Minefield set up**
 - 75 AT mines in 1.5 mines/meter front
 - No straight path through mine field passable by vehicle; no overlapping of mines
- **Breach**
 - Loss of all mines in a straight 5 meter wide lane
- **Healing process**
 - Minimize energy expended in healing and open no new lanes
 - Algorithm: Loss of nearest neighbor(s) initiates mine reorganization
 - 20% of time - full range
 - 20% of time - half range
 - 60% of time - mine stays in original position
- **Conclusion**
 - Self-Healing Minefield resistant to breaching attempt



Self-Healing Minefield - *Battlefield Utility*



- Lawrence Livermore National Laboratory simulated single scenario
 - No mines
 - Antitank only
 - Mixed system (Volcano)
 - Self-Healing Minefield
- Battle forces
 - Red force consists of a mechanized battalion
 - Blue force consists of 3 rifle platoons
- Battle designed to stress Blue

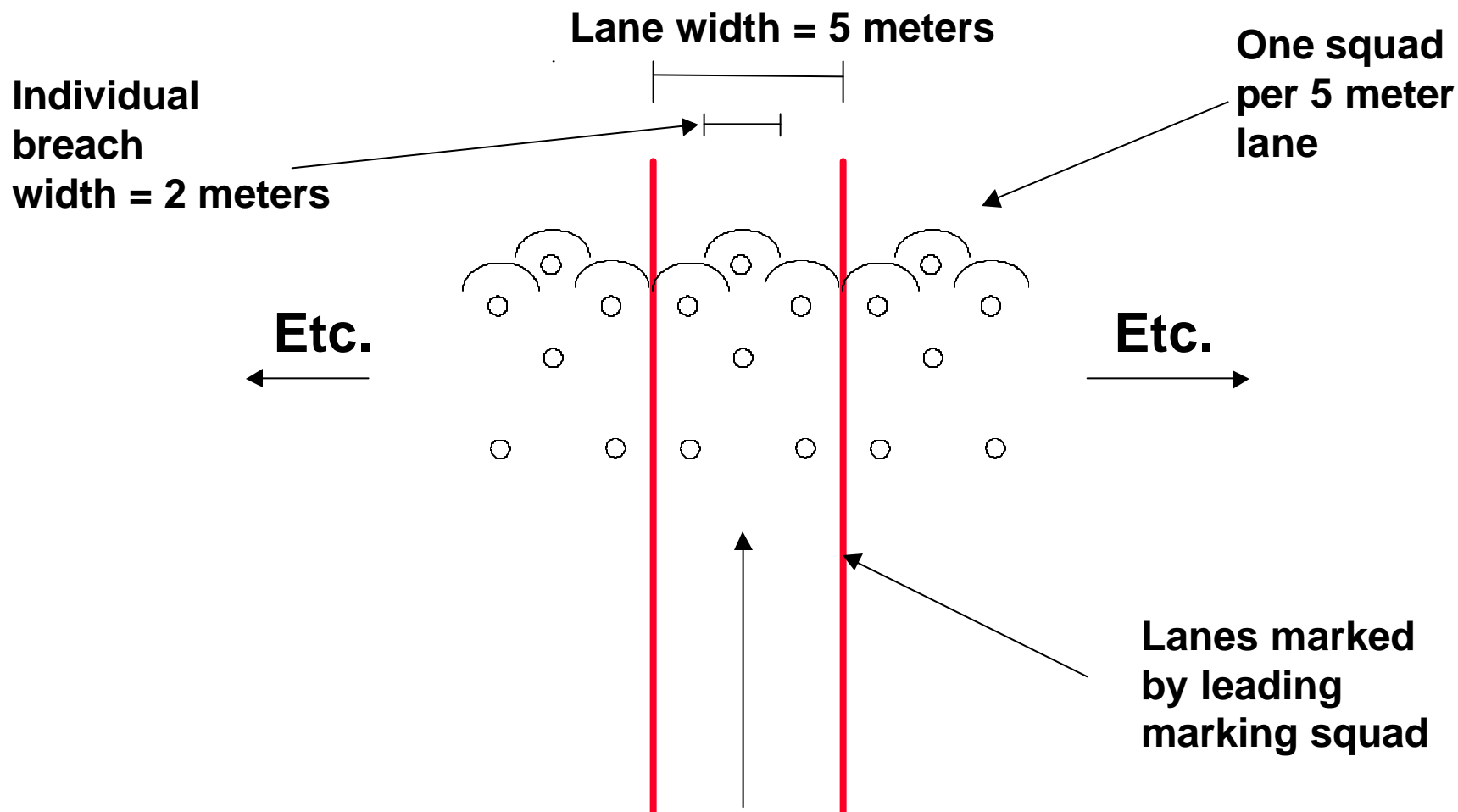




Self-Healing Minefield - Dismounted Breach Technique



Wide Area Breach

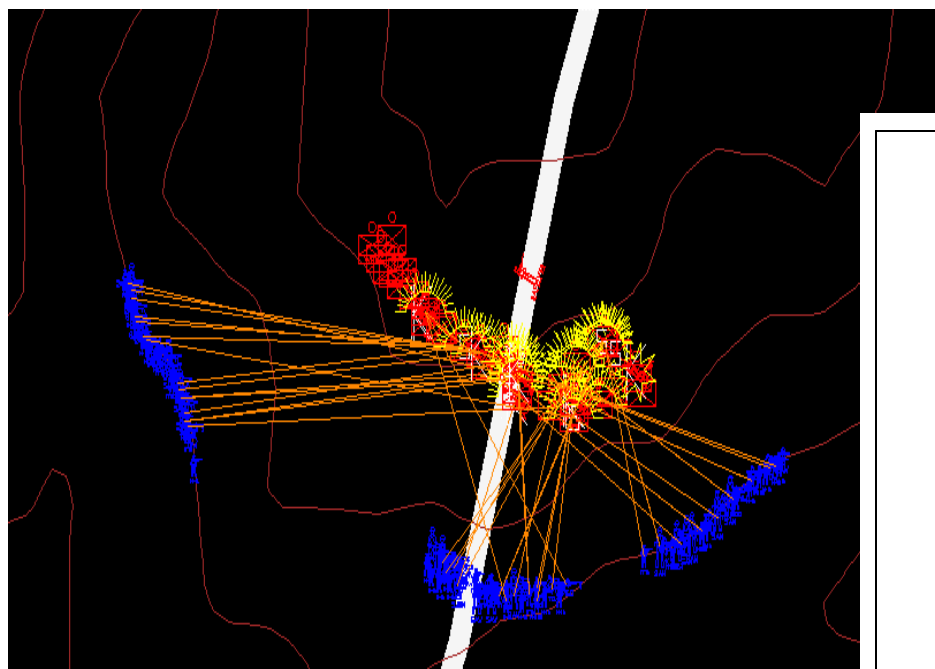




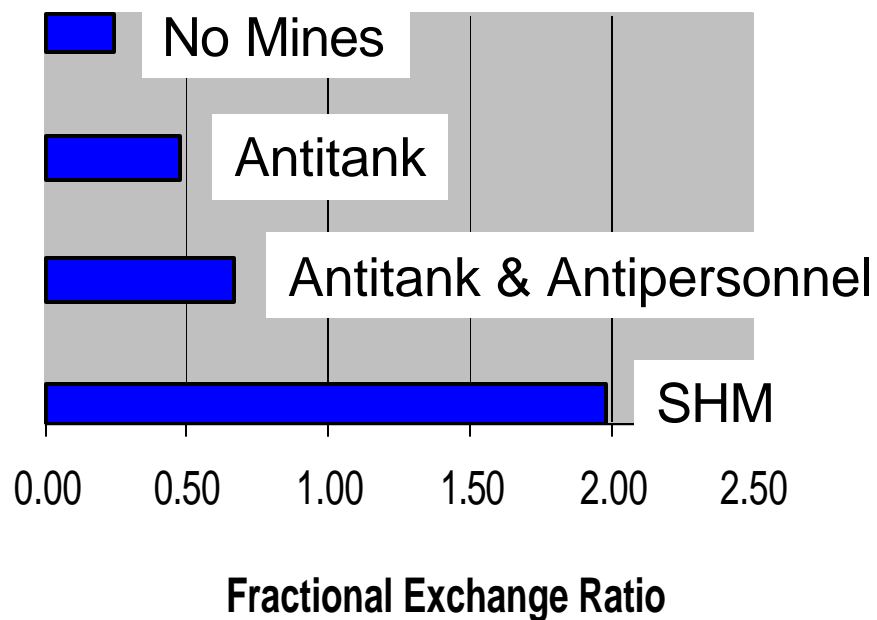
Self-Healing Minefield - Battlefield Utility



The Self-Healing Minefield increases Blue battle performance for this scenario



$$\text{Fractional Exchange Ratio} = \frac{\% \text{ Red Loss}}{\% \text{ Blue Loss}}$$





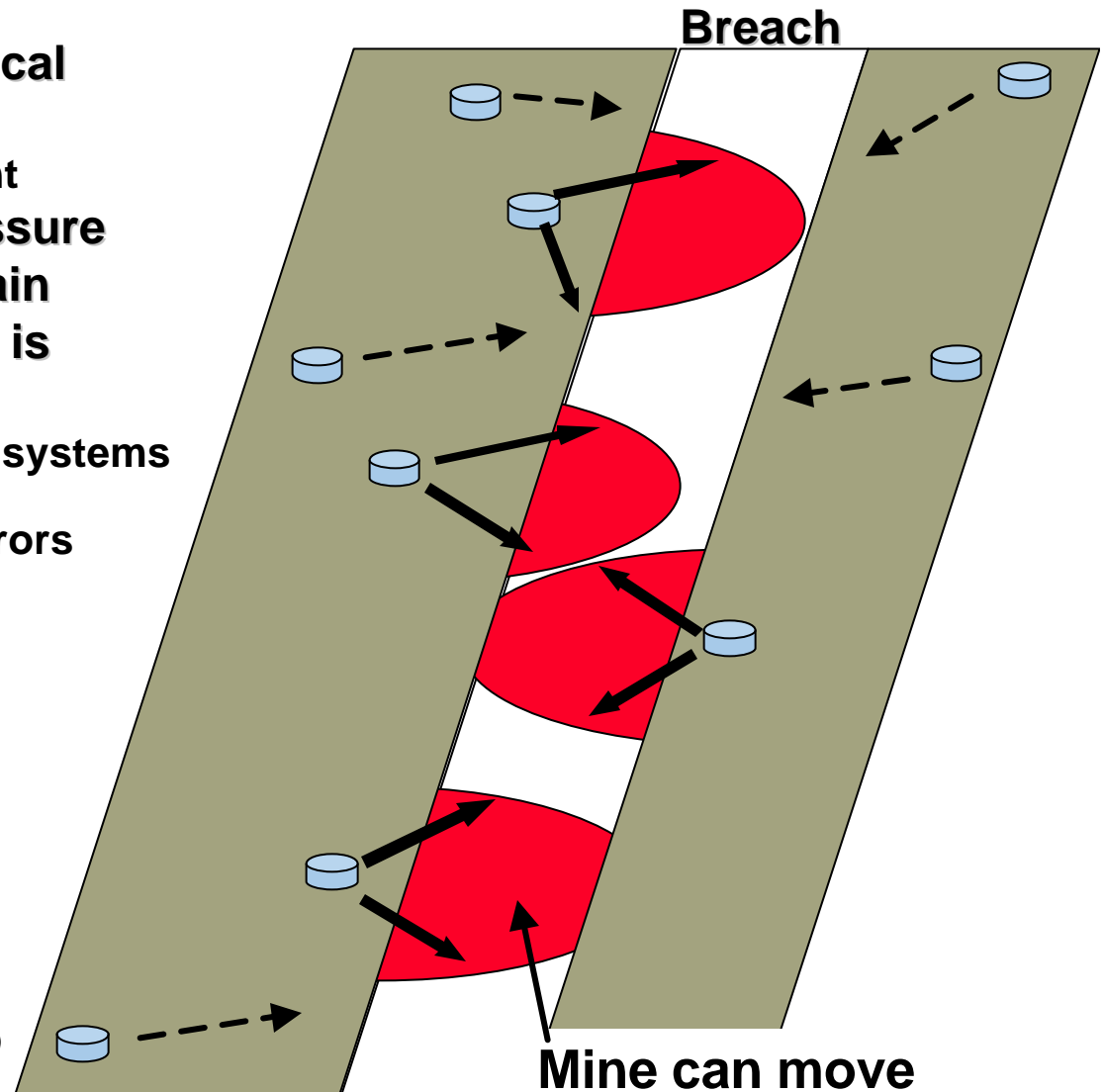
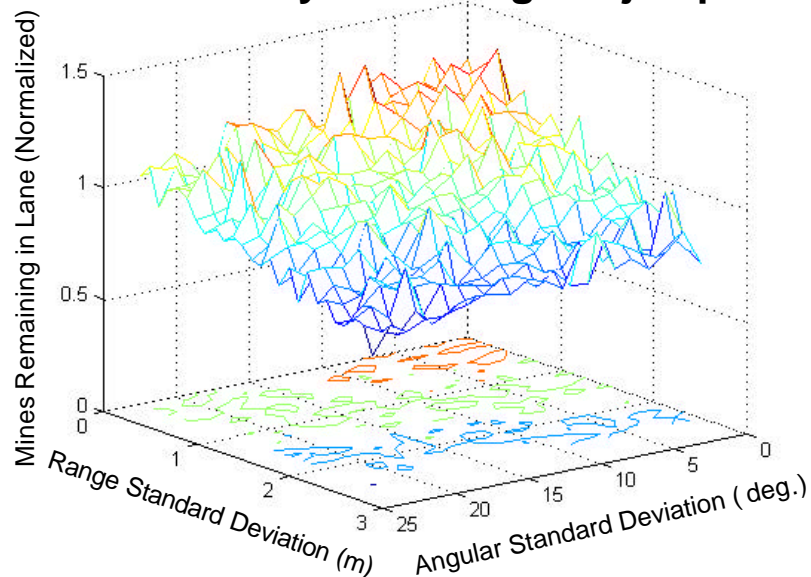
Self-Healing Minefield

- Mine Mobility Issues



- Minefield healing is a statistical process
 - System is highly fault tolerant
- Impulse based mobility to assure robustness in expected terrain
- Only simple mobility control is necessary
 - No need for complex robotic systems

Sensitivity of healing to “jump” errors



Mine can move
anywhere in annulus



Self-Healing Minefield

- *Developmental Issues*



Communications

- **Low power self-organizing communication network**
- **Distributed determination of mine location**
 - **Relative versus absolute geolocation**
- **Detection and localization of enemy breach**
- **Resistant to enemy countermeasures**
 - **Distributed jamming**
 - **Low probability of exploitation**
 - **Spoofing**

Behaviors

- **Autonomous control**
- **Time-lines for response to breach**
- **Vulnerability to manipulation/countermeasures**
- **Flexibility**

The Antipersonnel Landmine Alternatives Track II - *Conclusions*



- **The Self-Healing Minefield will prevent/impede a successful breach of an antitank minefield **WITHOUT** antipersonnel landmines**
 - **Assures a robust obstacle to disrupt enemy vehicles**